Reading: Averill 12.3; Shackelford 3.7 (Supplemental reading posted)

## 1. Why x-rays?

*Averill Chapter 12, Section 3, Conceptual Problem 5*

Why are x-rays used to determine the structure of crystalline materials? Could gamma rays also be used to determine crystalline structures? WHy or why not?

## 2. Why not visible light?

*Averill Chapter 12, Section 3, Conceptual Problem 6*

X-rays are higher in energy than most other forms of electromagnetic radiation, including visible light. Why can't you use visible light to determine the structure of a crystalline material?

## 3. Diffraction angle and x-ray source

*Averill Chapter 12, Section 3, Conceptual Problem 8*

It is possible to use different x-ray sources to generate x-rays with different wavelengths. Use the Bragg equation to predict how the diffraction angle would change if a molybdenum x-ray source (x-ray wavelength = 70.93 pm) were used instaed of a copper source (x-ray wavelength = 154.1 pm)

## 4. Bragg diffraction

*Averill Chapter 12, Section 3, Conceptual Problem 9*

Based on the Bragg equation, if crystal A has larger spacing in its diffraction pattern than crystal B, what conclusion can you draw about the spacing between layers of atoms in A compared with B?

## 5. Diffraction angle

*Averill Chapter 12, Section 3, Numerical Problem 11*

Calculate the angle of diffraction when x-rays from a copper tube ($\lambda$=154 pm) are diffracted by planes of atoms parallel to the faces of the cubic unit cell for Mg (260 pm), Zn (247 pm), and Ni (216 pm). The length on one edge of the unit cell is given in parentheses; assume first-order diffraction (n=1).

## 6. Interplanar spacing from scattering angle

*Averill Chapter 12, Section 3, Numerical Problem 12*

If x-rays from a copper target ($\lambda$=154 pm) are scattered at an angle of 17.23°by a sample of Mg, what is the distance (in picometers) between the planes responsible for this diffraction? How does this distance compare with that in a sample of Ni for which $\theta$=20.88°?

## 7. Diffraction angle of higher-order reflections

a) In a diffractometer experiment, a specimen of thorium is irradiated with tungsten $L_\alpha$ radiation. Calculate the angle, $\theta$, of the $4^{th}$ reflection.

b) Suppose that the experiment described in part (a) is repeated but this time the incident beam consists of neutrons instead of x-rays. What must the neutron velocity be in order to produce reflections at the same angles as those produced by x-rays in part (a)?

## 8. Wavelength of higher-order diffraction

What is the maximum wavelength $\lambda$ of radiation capable of second order diffraction in platinum (Pt)?

## 9. Electron diffraction

What acceleration potential (V) must be applied to electrons to cause "electron diffraction" on 220 planes of gold (Au) at $\theta$=5°?

## 10. x-ray spectrum

You are operating an x-ray tube with a Cr target by applying an acceleration potential (V) of 60 kV. Draw a schematic of the x-ray spectrum emitted by this tube; label on it three characteristic $\lambda$'s and give the numerical value of two of these.

## 11. Emission spectrum

a) You operate the x-ray tube from the previous problem at a plate voltage of 66 kV. Calculate the value of $\lambda_{SWL}$, the shortest wavelength.

b) Sketch the emission spectrum (intensity vs wavelength) for the Cr target. On the same plot, sketch the emission spectrum if an Ag target is used instead. On your sketch, indicate the relative positions of the $K_\alpha$, $K_\beta$, $L_\alpha$, and $L_\beta$ lines and $\lambda_{SWL}$. It is not necessary to calculate the $\lambda$ values of the $K_\beta$, $L_\alpha$, and $L_\beta$ lines.

c) In one or two sentences, explain the origin of the continuous spectrum.